Hearing Conservation

Industrial Aspects in California

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• **Impaired hearing is a serious problem. The number of persons with a significant hearing loss has been estimated to be approximately 10 per cent of the population.**

Hearing loss owing to exposure to noise is becoming an increasingly important disease. Although it has been recognized for more than a century, little if anything was done to prevent it until a few years ago.

The initiation of hearing conservation for employees has been undertaken by many of the large companies, particularly in California.

Hearing conservation includes preemployment and follow-up hearing tests, control of noise at the source and personal protection (ear plugs, ear muffs).

Noise-induced hearing loss is directly related to noise-exposure. Noise must be measured in terms of volume, wave length and length of exposure. Exposure must be analyzed for daily distribution and total time.

Although the noise-exposure problem is a serious one, cooperation of employee, employer and the legal and medical professions to initiate preventive programs can reduce it to a minimum.

OF THE MANY ILLS that have beset mankind, few have been as seriously misunderstood as impaired hearing. Although loss of hearing has been known since the time of early recorded history, present knowledge of the disease before the sixteenth century is very incomplete; much of what is known today is indirect or has been inferred.

The extent of hearing loss in our society may be estimated from the results of hearing surveys of school children and of the general population. Five to 10 per cent of the school children have sufficient hearing loss to be referred to an otologist; the Veterans Administration compensates 90,000 veterans for impaired hearing; nearly every state has at least one school for the deaf, with a total enrollment of over 100,000 students. A conservative estimate of the number of persons who require hearing amplification for effective communication is about 10 per cent of the total population of the United States, or some 17 million persons. Most persons are affected to some degree by hearing loss, in themselves or in a friend or relative.

The particular need for conservation of hearing in environments of noise which might be considered contributory to hearing loss has been emphasized recently by decisions handed down by the compensation courts in several states. Such bodies in Wisconsin and New York, for example, have declared that "occupational hearing loss" is compensable. In Wisconsin the law that governs payment of compensation for occupational hearing loss has been revised and extended. Such trends have aroused a new and vigorous interest in the problem of the relations of hearing loss to exposure to noise. It has long been known that extended exposure to many industrial noises will cause impairment of hearing. There are reports of noise-induced hearing loss dating as far back as 1804, when Fosbrooke of England reported that blacksmiths as a group had impaired hearing. The modern blacksmith, the drop forge operator, is still a subject of concern in studies of noise-induced hearing loss.

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THE LEGAL HISTORY

Although the medical history of noise-induced hearing loss is fairly clear and there is no doubt in the minds of anyone that hearing loss will result from noise-exposure, legally the problem is much more complex and not so clear. Terms such as *disability* and *occupational disease* when used in the legal sense have a meaning entirely different from the medical meaning. For example, the term *disability* as used in the medical sense indicates a dysfunction of some particular organ or impairment of a physiological process of the body. In the legal sense, disability may not mean the same. Within a legal framework loss of function or injury to the human body becomes a disability only if defined as such by law. This is true of the term *occupational disease* also. We may be correct in saying that a loss of function is occupationally induced, but legally that loss of function need not be an occupational disease. What might be classed as an occupational disease or a disability in one state will not necessarily be so classed in another.

It is unquestioned that hearing loss reduces a man's capacity to live a normal life, and in some

specific instances may reduce his earning capacity; but if the legal criteria used in many states for establishing disability are applied to noise-induced hearing loss, it is not a disability. There is no date of injury nor, in most cases, is there loss of wages. On the other hand, there is no question that hearing loss can be occupationally induced.

A discussion of the legal aspects of disability would be incomplete without mention of the "compensation for wage loss" concept—the original intent of compensation laws. From the inception of workmen's compensation laws in the decade between 1910 and 1920 until the case in New York state in 1948 there had been few departures from the wage loss concept. However, when the New York claimant received compensation with no date of injury and certainly no wage loss, it was evident that the wage loss concept was in for re-examination. Further, when the state of Wisconsin decided in favor of a claimant under similar conditions, serious doubt was cast on the use of loss of wages as a basis for establishing compensation. Heretofore, this concept had acted as a brake which could be depended upon to limit compensation within reasonable bounds. With these interpretations, however, it appeared that industry was in danger of serious financial embarrassment were the wage loss concept completely abandoned.

It is not our right as physicians to discuss disability as defined on a legal basis, in contrast to social handicap which depends upon a man's relation to his total life. Much of what we might say could be biased. As physicians it is our duty to preserve man's various functions and restore them whenever possible. As physicians we cannot and should not relate loss of function to dollars and cents. We must evaluate loss of function by the effect on the patient. On the other hand, we are members of the community and are in this capacity concerned also with loss of function as it affects the community. What the community can afford to pay for loss of bodily function and whether payment shall be based upon man's relation to his industrial life or to his total life must be regulated by community opinion. As members of the community we might argue that compensation benefits must be based upon the opinions of the whole community, not only the industrial community. After all, the employee is a member of the industrial community for only a small part of his lifetime; but he remains a part of the total community for his entire life. As physicians, we must urge that the industrial community do everything possible to preserve human functions. We should be impartial in our decisions regarding all members of the industrial community, which includes employee and employer alike. Our concern is conservation, not compensation. Much of what we do will influence the results of the application of compensation laws to employer and employee; but whether the laws are based on wage loss or social loss must be decided upon primarily by the total community.

There are two principal variables in the industrial noise problem: Noise-exposure and noise-induced hearing loss. Noise-exposure has two principal dimensions: Sound pressure level and time. The sound pressure is measured in decibels by a sound level meter. The distribution of the sound pressure as a function of frequency or pitch is measured at octave intervals in decibels with an octave band analyzer, which is a series of filters arranged to eliminate all frequencies except those in the octave band that is being measured. Exposure time should be thought of in terms of daily distribution and total lifetime duration. Both are important. Present evidence shows that interrupted exposure during a work day is not as hazardous as continuous exposure, even though the former may have considerably higher sound pressure levels.

For purposes of conservation of hearing in industry, hearing is measured by pure tones in decibels. The pure tone tests are given with the use of an audiometer. This instrument is designed to measure the auditory threshold at discrete frequencies throughout the central section of the audible spectrum, which extends from 20 to 20,000 cycles per second. Most audiometers are calibrated to measure hearing loss at 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 cycles per second in five-decibel steps. The decibel is a unit used to measure sound pressure level. It is a logarithmic expression of a power ratio. It is not a linear unit, but indicates increases from a reference point by a factor of 10. Sound pressure levels are usually related to 0.0002 dynes per square centimeter—the least sound pressure the ear will respond to at 1,000 cycles per second.

The effects of noise-exposure are usually divided into nonauditory and auditory effects.

The nonauditory effects may be divided into those that modify communication by speech and those that cause changes in behavior. That excessive noise interferes with speech is readily apparent; but the behavioral effects are not so obvious. For example, noise is said to cause excessive fatigue, neurosis, sterility, "nervousness" and even insanity. In a review of the literature it is notable that almost anything can be ascribed to exposure to noise; but no one has presented any controlled data to substantiate any of the claims. There are so many other factors that are coexistent with noise that no valid conclusions can be drawn. It is quite clear, though, that in the majority of industrial situations exposure to noise is not a factor in behavioral upsets.

The auditory effects of exposure to noise are well

known. Noise-exposure does have effect on the inner ear that brings about hearing loss of a type not amenable to treatment. The amount of exposure it takes to cause how much hearing loss in what person is not so easy to establish, however.

There are many factors that make the answer to questions such as these very difficult to obtain.

Amount of Noise-Exposure

The combination of noise and exposure expresses an extremely important concept which physicians would do well to remember. Rarely does noise-induced hearing loss come about without long exposure. In general, the length of the exposure required to bring about impairment of hearing is inversely proportionate to the amount of energy in the noise. To complicate this simple concept, however, noises differ from each other and so do people. For example, the noise energy may be located in one or two bands of frequencies or may be distributed throughout eight or more bands of frequencies. To determine this, noise must be measured in two dimensions—total energy and frequency characteristics. Further, the exposure may be distributed differently—time during a work day or total during a work life. Noise-induced hearing loss is a slowly progressive insidious process. Significant losses do not commonly occur as a result of a single or short term exposure unless the exposure is explosive in nature.

Susceptibility

Most persons are susceptible to noise-induced hearing loss. Some few persons can take a lot of exposure to excessive noise without having significant hearing loss; on the other hand, a few will have considerably more loss than the average. My observation is that the number at either extreme is quite small.

Definition of "Hearing Loss"

Strictly speaking, deviation toward an increase in the auditory threshold can be said to be a hearing loss. However, physicians are concerned principally with preventing significant hearing loss—loss that causes a handicap. The amount of hearing loss it takes to cause a handicap is significantly more than a mere increase in threshold above the zero on the audiometer. This zero, or average normal hearing reference, is a statistical average and, therefore, not a specific point on a scale. Any threshold that lies within 15 decibels of zero, above or below, can be said to be within normal limits. Loss of acuity greater than that represented by 15 decibels above zero can be considered a handicap. Now to define *handicap.*

The most important function of the ear in our society is to hear speech for communication purposes. Hence, it would be desirable to know how much noise-exposure is necessary to produce a hearing loss sufficiently great to cause a handicap for communication by speech in the average person.

This question cannot be answered as yet; it is possible only to suggest tentative limits which will indicate when a noise-exposure may be potentially hazardous and necessitate hearing conservation measures. On this basis, I suggest that if a person is to be exposed continuously for several hours a day for many years to noise of 85 decibels or more in the 300 to 600 and 600 to 1,200 frequency bands, hearing conservation measures are in order.

Hearing conservation programs should include: (1) A noise-exposure analysis, (2) control of noise-exposure, (3) the measurement of hearing.

A noise-exposure analysis entails measuring the volume of noise, determining what portion of the volume is borne on the various wave lengths (frequencies), the distribution by time during the day (is it continuous or intermittent?), and the total duration during a work-life.

Control of noise-exposure may be accomplished by reducing the noise at the source and/or protecting the exposed person. Reducing the amount of noise at the source is an engineering job and, if feasible, is obviously the best solution. Usually, however, the most practical method of noise-exposure control is through personal protection. This may be accomplished by isolating the person in specially constructed booths, where possible, or, most practical of all, by promoting the use of ear-plugs or ear-muffs. As with every other personal protective device, it is often difficult to get the worker to use protective equipment at first, but experience has shown that with a little effort and patience most employees will eventually wear ear protection faithfully. Ear plugs or muffs rarely cause any difficulty and with reasonable care, may be worn continuously under any condition.

The measurement of hearing is undoubtedly the most important part of a hearing conservation program. Without audiometric examination it is impossible to evaluate the efficacy of the noise-exposure control methods. Pre-employment hearing tests should be given to every employee regardless of the nature of his prospective employment. Pre-employment audiograms serve to establish the status of the employee's hearing for use in case of medico-legal proceedings and act as a baseline for comparison with subsequent follow-up tests. Follow-up tests should be given periodically—at 90 days after starting work in a noisy area and then routinely once a year. These follow-up tests will monitor the efficacy of a hearing conservation program and indicate

whether the employee should be checked oftener as regards ear protection or in some cases indicate the need of a transfer into less noisy surroundings.

Pre-placement audiograms require air conduction threshold tests at 500, 1,000, 2,000, 3,000, 4,000, and 6,000 cycles per second. They may be given with a simple standard screening audiometer. Diagnostic audiograms should not be a routine part of an industrial program. These should be made only on request and usually by or under the supervision of an otologist. Follow-up tests are given to detect changes from the original, or baseline audiogram. They may be done by simply screening with 20 decibels at 4,000 cycles per second. This single frequency screening serves for rapidly testing many employees in a short time. Research has shown that most noise-induced hearing loss occurs at 4,000 cycles per second. Surveys have proved that 99 per cent of employees will show more hearing loss at 4,000 cycles per second than at any other frequency. The single frequency screening test has many advantages. (1) The equipment costs considerably less than other types; (2) screening at 4,000 cycles per second at 20 decibels may be done in ordinary quiet rooms. Sound-treated rooms such as those required for threshold tests are not necessary; (3) the test can be given in a few seconds; (4) there is no need for trained personnel.

Many companies even in as enlightened a state as California are hesitant about initiating a hearing conservation program because of the fear of increasing the number of claims for hearing loss. This can be called the "ostrich syndrome." There are numerous large companies in California that have had hearing conservation programs in force for ten to fifteen years. All of them say there has been no increase in claims due to the program. On the contrary, they feel certain the programs have saved a great deal of money.

California has had an occupational disease law for over ten years. It is a very liberal law, providing not only for compensation on an occupational disease basis but also for any subsequent medical care which might result from the occupational disease. For example, if a claim is recognized, the claimant may obtain a hearing aid with all the necessary services, such as batteries and repairs. Frequently, these ancillary costs are far greater than the actual award.

The seriousness of the hearing loss problem cannot be over-emphasized. A flood of claims could very well wreck a company financially. The total cost could be many millions of dollars. In my opinion, however, with a reasonable attitude toward compensation and good hearing conservation programs the potential risk can be reduced to a minimum. The final solution rests with the cooperation of all concerned—the employee, the employer, the compensation commissions, legislators and the legal and medical professions.

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